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Carbon Fiber Insoles Enhance Perception of Performance Despite Variable Objective Outcomes: Specific to the Moderately Active Individual

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ABSTRACT

International Journal of Exercise Science 16(4): 885-897, 2023. Carbon fiber insoles (CFIs) may benefit performance in elite athletes, however, their use in moderately active individuals has been adopted without evidence supporting such enhancements in this population. Fifteen male subjects performed vertical jump (VJ) and repeat treadmill sprint tests before and after a VO_{2peak} while wearing 1) CFIs and 2) control insoles (CON). Subjects completed a subjective survey regarding their perceived performance abilities for both conditions. There were no significant differences between CFIs and CON in VJ height, sprint distance, heart rate following sprints; and rate of oxygen consumption, perceived fatigue, and perceived exertion at 85% of maximal speed ($p > 0.05$) during the VO_{2peak}. At maximal speed, although there was no difference between conditions in peak rate of oxygen consumption (95%CI [-4.85, 0.21]) and respiratory exchange ratio (95%CI [-0.01, 0.03]), CFIs resulted in a reduced level of perceived fatigue (95%CI [-1, 0]) and perceived exertion (95%CI [-2, 0]) compared to CON. Subjects subjectively reported increased feelings of "*propulsion or explosiveness*" ($p = 0.026$) and being able to "*perform better while jumping*" ($p = 0.029$) while wearing CFIs. Heightened perceptions of performance enhancements when wearing CFIs indicate, in the moderately active, perceptual benefits could be more influential for determining CFI use.

KEY WORDS: Vertical jump, repeated treadmill sprint, VO_{2peak}, subjective response, shoe insole

INTRODUCTION

The global market for foot orthotic insoles reached 3.25 billion U.S. dollars in 2019 and is projected to grow to 4.5 billion by 2027 (50). While many materials (e.g., foam, ethyl-vinyl acetate, thermoplastics) and applications (e.g., medical, sports, personal) for foot orthotics exist, the use of carbon fiber for performance enhancements has gained momentum. Specifically in the broader population, carbon fiber insoles (CFIs) and shoes with embedded carbon fiber plates are increasingly more popular and accessible as well-known brands advertise performance enhancements when wearing their carbon fiber product (e.g., VKTRY, Performance Insoles®; Superfeet, Carbon®; Nike, Zoom Vaporfly NEXT%®; Brooks, Hyperion Elite 2®; Hoka One One, Carbon X2®; New Balance, FuelCell RC Elite v2®). The purpose of the carbon fiber materials is to provide rigidity to the sole, typically either across the length of the foot (i.e., insoles) or on the midsole (i.e., embedded plates). This increased bending stiffness has been suggested to decrease energy loss (40,42), increase energy return (9,10,48), and potentially reduce the amount of work required in the midsole region of the foot (8). Furthermore, carbon fiber provides a lightweight option to maintain a lower overall shoe mass with the objective to minimize the energetic cost of the shoe (14). Given these concepts, however, the effects CFIs have on actual performance outcomes remains unclear, specifically within populations of different athletic ability (e.g., moderately active individuals to elite athletes).

Performance measures vary within the literature, however, assessments of jumping, sprinting, and running economy are most common and applicable across various sports and activities. Through the mechanism of decreasing energy loss and increasing energy return, it has been hypothesized that insoles with increased bending stiffness can improve vertical jump (VJ) and sprint performance. While studies assessing both CFIs and embedded carbon fiber plates have shown improved single-leg vertical jump (VJ) height (18,40), another study failed to see an effect of stiff insoles on two-leg VJ height or broad jump length (45). These discrepancies may stem from less bending of the metatarsophalangeal joint during two-legged jumps that results in less mechanical energy stored and returned during the jump. Although one study demonstrated CFIs result in improved performance in a short-distance sprint (18), it has also been shown that there is no difference in short-distance sprint speed between stiff insoles and their control counterpart (45). Furthermore, by shifting ground reaction force lever arms of the ankle joint anteriorly during the push-off phase of running (47), insoles with increased bending stiffness may improve energy storage and return in the Achilles tendon thereby reducing the energy demand required (35). Previous investigations support the effect of a potential optimal bending stiffness on reducing the metabolic cost of running (21,29,34), however, other studies report limited to no effects of embedded carbon fiber plates on running economy, the oxygen requirement at a given velocity (1,8–10,13,31).

Comparisons of studies reporting the effects of carbon fiber foot orthotics on performance should consider differences in stiffness level of the insole (28,47), testing of CFIs versus embedded carbon fiber plates, type of shoe tested in, and other properties of the orthotic (e.g., other materials incorporated, mass, shape, design). Additionally, moderators such as running speed (31), body mass (34), and an individualized optimal stiffness level (18,45) may result in individual variances in performance outcomes. To the authors' knowledge, the literature to date assessing specifically CFIs is limited (18,42,47,48). Furthermore, evaluations of the effects of increased bending stiffness on VJ and sprint performance has been primarily limited to elite athletes and/or athletes from specific sports (18,40,45), thereby making their effects on performance in moderately active individuals unclear.

In addition to objective performance outcomes, the subjective performance when wearing CFIs may play a significant role in an individual's usage and overall satisfaction. Subjective measures, such as the Borg Rating of Perceived Exertion scale (5) and Likert rating scales for fatigue (25), provide valuable insights into an individuals' subjective experience during exercise. Numerous studies have successfully used these subjective measures to assess exertion and fatigue in various exercise contexts, providing valuable information beyond objective performance measures alone (20,36,37,46,49). While assessments of individual perception of ergogenic aids have not attained the same extensive use and research as those of exertion and fatigue, various studies utilizing Likert-type scales and other methods have demonstrated the significance of perception in performance, injury prevention, and overall user experience (2,23,24). Assessing perception of performance with CFIs in a moderately active population is particularly important given the increasing accessibility and appeal of CFIs across the broad population. However, despite their widespread popularity, an evaluation of these subjective factors remains lacking. Therefore, the purpose of this study was to investigate the effects of wearing CFIs on performance and perception, specifically in moderately active participants. We hypothesized that VJ height and sprint distance would improve when wearing CFIs compared to the control and that CFIs would mitigate VJ and sprint performance detriments following a peak aerobic power test (VO_{2peak}). In addition, we hypothesized CFIs would result in improved running economy measured during a VO_{2peak}. Lastly, we hypothesized participants would have positive perceptions of CFIs relating to performance.

METHODS

Using a crossover study design, this study explored whether CFIs improved objective (VJ, sprint distance, running economy) and subjective (perceptual scales, consumer survey) measures of performance compared to a control insole. After providing informed consent, participants underwent a familiarization trial while wearing self-selected exercise shoes, followed by the completion of two test trials in a randomized order. During the control (CON) trial, participants wore standardized shoes (New Balance 1400v6 RevLite, Boston, MA) with the factory-made insoles. For the carbon fiber insole (CFI) trial, participants wore the standardized shoes with a commercially available insole (VKTRY Performance, Milford, CT, USA), which the company uses a proprietary method to match stiffness to the participant's body mass. Participants were given and asked to wear the respective insoles and shoes as their primary footwear for approximately 10-14 days prior to each trial to allow time for adaptation with each insole condition. Participants were asked to avoid intense exercise and consume their relative average diet during the 24 hours prior to each trial.

Participants

Fifteen male participants (mean ± standard deviation [SD]; age = 24 ± 6 years; height = 171.1 ± 3.0 cm; mass = 81 ± 12 kg) recruited from the University campus and local community were included in this study, which was approved by the institutional review board at University of Connecticut. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (27). An *a priori* power analysis was performed using G*power (Dusseldorf, Germany) to determine appropriate sample size. Prior research with similar methods examining differences between insoles and a control on performance and perception were used for the calculations (34,40,44). With an alpha of 0.05 and a desired power level of 0.8, a sample size of 15 was determined. Inclusion criteria consisted of individuals aged

18-40 years who reported engaging in moderate physical activity 3-5 times per week, had no history of lower extremity injury in the previous 6 months, and exhibited a self-reported heel-toe running pattern consistent with previous literature (34). The running pattern was visually confirmed by investigators during the initial visit. Exclusion criteria included any current musculoskeletal injury that would limit physical activity or individuals with a history of cardiovascular, metabolic, or respiratory disease.

Protocol

Each trial (familiarization, CON, and CFI) consisted of a standardized warm-up, pre-performance battery, VO_{2peak}, and post-performance battery. The performance battery included countermovement vertical jumps (VJ) and repeated treadmill sprints, conducted in the same order before (PRE) and immediately after (POST) the VO_{2peak}. The familiarization trial aimed to acquaint participants with the protocol by performing the warm-up and performance battery in a manner consistent with the subsequent CON and CFI trials, ensuring participants were oriented to the procedures and promoting standardization across all experimental sessions. Additionally, the familiarization trial established the relative initial speed and speed increments to be used in the subsequent CON and CFI trials for each participant.

Similar to the protocol used by Wannop et al. (45), the VJ test involved the participant standing with their toes in line with the post of the measurement device (Vertec Vertical Jump Tester, Gopher Performance, Owatonna, MN, USA). When instructed, the participant performed a VJ by bending their knees and immediately jumping as high as possible to hit a marker with their outstretched dominant hand. The participant rested passively for approximately 45 seconds between jumps to facilitate recovery of the ATP-PCr and neural systems yet maintain neuromuscular activation and psychological readiness (7). The highest VJ height out of three attempts was recorded and used for analyses in both the CON and CFI trials.

The repeated treadmill sprints consisted of maximally sprinting for 6 seconds, with a total of five sprints performed on a non-motorized treadmill (Woodway Curve Treadmill; Woodway Inc., Waukesha, WI, USA). Each sprint commenced from a stationary start position without holding the rails. Following each sprint, a 24-second period of active recovery, either walking or slow jogging based on participant preference, was performed. This protocol was adapted from a previous study (41). Given that the non-motorized treadmill utilized in this study did not offer precise distance tracking, an alternative method was employed to accurately measure sprint distance (3). Reflective tapes of distinct colors were placed equidistantly on each side of the treadmill belt to mark full and half revolutions. To ensure accurate measurement, an investigator visually tallied the belt repetitions using a pitch counter while the participant performed each sprint. Each half revolution of the treadmill corresponded to 1.8 meters. This approach was necessary to obtain reliable and detailed sprint distance data in the absence of advanced distance-tracking capabilities on the non-motorized treadmill. Heart rate (Wahoo Tickr, Atlanta, GA) was recorded immediately after each sprint. The distance covered during the fastest sprint and the heart rate measured after the final sprint were used for analyses in both the CON and CFI trials.

Participants performed a VO_{2peak} on a motorized treadmill (Bertec Instrumented Treadmill; Bertec, Columbus, OH, USA) with a 0% incline. During the familiarization trial, participants were given the opportunity to try different initial speeds to select their subjective perception of a moderate jog, allowing them to proceed for approximately four additionally 3-minutes stages with incrementally increasing speeds until reaching volitional exhaustion (38). The approach aimed to establish the participant's maximal exertion with a target duration of approximately 15 minutes, thereby inducing acute cardiorespiratory fatigue. Speed was increased by 0.2 $m \cdot s^{-1}$ (equivalent to about 0.5 miles $\cdot hr^{-1}$) every 3 minutes until volitional exhaustion. Consistency was maintained by using the same starting speed and speed increments for both the subsequent CON and CFI trials within each participant. For each VO_{2peak} participants were fitted with a two-way non-rebreather mask connected to a metabolic cart (TrueOne, Parvo Medics, Salt Lake City, UT) that was worn throughout the test. Rate of oxygen consumption (VO_2) and respiratory exchange ratio were calculated using 30-second averages from the final minute of each 3-minute stage. Reliable measures of running economy must be obtained at speeds ≤ 85% of VO_{2peak} (35). Therefore, in addition to the values collected at the maximal speed during the VO_{2peak}, measures at approximately 85% of their maximal speed (since speeds were increased by increments of 0.2 $m \cdot s^{-1}$, the speed of the stage that fell closest to 85% of their maximal speed was used) were analyzed and interpreted as the running economy. Heart rate, perceived fatigue using a Likert rating scale from 0 to 10 (25), and perceived exertion using the Borg Scale from 6-20 (5) were recorded during the final 30 seconds of each stage.

Participants were asked to complete a subjective survey at the beginning of each trial that asked questions regarding the comfort, feel, performance and functionality of the insoles they had been wearing since their last visit. The scale ranged from 1 = strongly disagree to 7 = strongly agree. Participants were allowed to ask for clarification if any of the questions were unclear to them. The survey was created in collaboration of three content area experts from the Korey Stringer Institute and one expert from VKTRY Performance.

Statistical Analysis

SPSS Version 28 was used for all statistical analyses. All data were reviewed for normality of distribution using the Shapiro-Wilks test, and no variables violated the standard guidelines. Separate 2-way ANOVAs (time by condition) with post-hoc planned pairwise comparisons were used to assess all parametric variables with significance set at $p \leq 0.05$, *a priori*. Results were reported as mean differences (MD) ± standard deviation (SD) with 95% confidence intervals (CI). In addition, paired t-tests were used to analyze VO_2 values, respiratory exchange ratio, perceived fatigue, and perceived exertion between insole conditions. Wilcoxon Rank Sum test was used to analyze nonparametric data (consumer survey responses) and results were reported using medians and interquartile ranges (IQR).

RESULTS

There was an interaction in VJ height ($p = 0.054$) indicating a higher VJ at POST compared with PRE in the CON condition only ($p = 0.015$, MD = 1.8 ± 2.6 cm, 95% CI [0.4, 3.3]; Figure 1).

Although no significant differences were observed for sprint distance ($p > 0.05$), there was a significant condition x time interaction in heart rate following sprints ($p = 0.048$). In both CFI and CON, heart rate following sprints was greater POST compared to PRE ($p = 0.032$, MD = 5 ± 8 bpm, 95% CI [1, 10]; $p < 0.001$, MD = 13 ± 10 bpm, 95% CI [7, 19], respectively; Figure 2, Table 1).

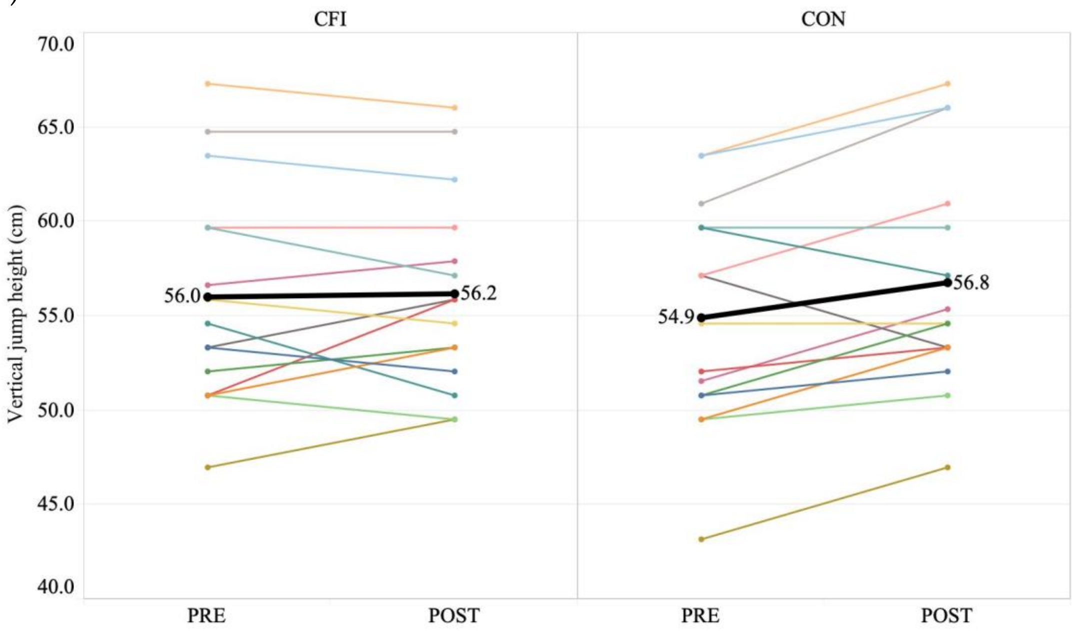

Figure 1. Significant increase in vertical jump from PRE to POST only in the control (CON) condition ($p < 0.05$). Mean values: black line, individual values: colored lines. *CFI* carbon fiber insole condition, *CON* control condition, *PRE* prior to peak aerobic power test, *POST* following peak aerobic power test.

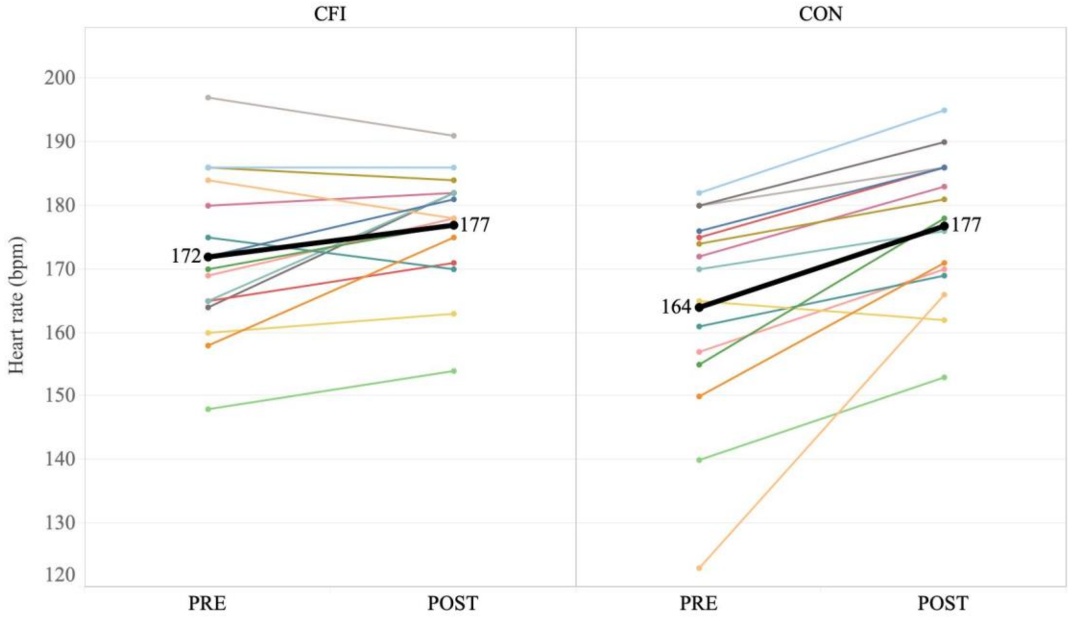

Figure 2. Heartrate following repeated sprints significantly increased from PRE to POST in both conditions ($p < 0.05$). Mean values: black line, Individual values: colored lines. *CFI* carbon fiber insole condition, *CON* control condition, *PRE* prior to peak aerobic power test, *POST* following peak aerobic power test.

Table 1. Comparison of performance measures by condition (CFI vs CON) within time (PRE and POST), mean (SD)

	PRE				POST			
	CFI	CON	MD	95%CI	CFI	CON	MD	95%CI
VJ (cm)	56.0 (5.9)	54.9 (5.9)	1.1 (2.8)	-0.5, 2.7	56.2 (5.2)	56.8 (6.9)	0.6 (2.5)	-2.0, 0.8
Sprint (m)	29.1 (5.4)	29.4 (4.7)	0.3 (3.2)	-2.0, 1.5	29.3 (4.4)	28.6 (3.9)	0.6 (3.1)	-1.1, 2.3
HR (bpm)	172 (13)	164 (17)	8 (18)	-2, 18	177 (9)	177 (12)	0 (7)	-4, 4

Note. CFI carbon fiber insole condition, *CON* control condition, *PRE* prior to peak aerobic power test, *POST* following peak aerobic power test, *VJ* maximum vertical jump height, *Sprint* maximum sprint distance in 6 seconds, *HR* heart rate following repeated sprints, *MD* mean difference.

Table 2. Comparison of physiological and perceptual measures during peak aerobic power test (VO_{2peak}) between conditions (CFI vs CON), mean (SD)

	85%				Final			
	CFI	CON	MD	95%CI	CFI	CON	MD	95%CI
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	37.29 (8.07)	38.58 (6.70)	1.29 (4.29)	-3.66, 1.09	42.65 (5.42)	44.97 (7.14)	2.32 (4.56)	-4.85, 0.21
RER	0.91 (0.04)	0.88 (0.05)	0.03 (0.04)	**0.01, 0.05**	0.97 (0.04)	0.96 (0.03)	0.01 (0.04)	-0.01, 0.03
Fatigue	4 (2)	4 (2)	0 (1)	-1, 1	8 (1)	9 (1)	1 (1)	**-1, 0**
RPE	13 (2)	13 (3)	0 (2)	-1, 1	17 (2)	18 (1)	1 (1)	**-2, 0**

CFI carbon fiber insole condition, *CON* control condition, *VO_2* rate of oxygen consumption, *RER* respiratory exchange ratio, *Fatigue* perceived fatigue, *RPE* rating of perceived exertion. *85%* refers to the measures obtained during the speed that corresponded to 85% of the maximal speed. *Final* refers to the measures obtained at the maximal speed of the VO_{2peak}, *MD* mean difference. *Bolded text* denotes significant difference between conditions ($p < 0.05$).

Table 3. Survey responses between conditions (CFI vs CON), median (IQR)

Survey Question	CFI	CON	*p*
I feel like I perform better when wearing these insoles while running	4 (2)	5 (1)	0.715
I feel like I perform worse when wearing these insoles while running	3 (2)	3 (2)	0.689
I feel more propulsion or explosiveness when wearing these insoles	5 (2)	4 (1)	**0.026**
I feel like I perform better when wearing these insoles while jumping	5 (2)	4 (1)	**0.029**
I feel like I perform worse when wearing these insoles while jumping	3 (3)	4 (3)	0.829

CFI carbon fiber insole condition, *CON* control condition. *Bolded text* denotes significant difference between conditions ($p < 0.05$).

Participants subjectively reported increased feelings of "*propulsion or explosiveness*" and increased feelings of being able to "*perform better while jumping*" while wearing the CFI versus the CON insole (Z = -2.22, *p* = 0.026; Z = -2.18, *p* = 0.029, respectively; Table 3).

DISCUSSION

The purpose of this study was to investigate the effects of wearing CFIs on running performance, jump performance, and perception, specifically in moderately active participants. Our findings demonstrate that CFIs did not affect quantitative performance measures (VJ, sprint speed, or VO_2) when compared to the CON insoles. However, participants reported reduced perceived fatigue and exertion when wearing CFIs during maximal speed running. Furthermore, participants expressed increased feelings of "*propulsion or explosiveness*" and being able to "*perform better while jumping*" when wearing CFIs. These findings highlight the meaningful impact of CFIs on subjective perceptions of fatigue, exertion, and performance, providing valuable insights into the potential benefits of CFIs in enhancing the overall exercise experience.

In this sample of moderately active male participants, CFIs did not result in improved VJ or repeated treadmill sprint performance compared to the CON insoles. Our findings differ from recent studies observing performance improvements when wearing insoles with increased bending stiffness, but those studies were conducted in samples of well-trained or college athletes (17,18,40,45). While large standard deviations in this study suggest a wide range of performance variability in less-trained individuals, further research directly comparing moderately active individuals and elite athletes is needed to determine if skill or fitness level influence potential effects of CFIs. This concept of individualized effects has previously been supported (6,12,18,45) and suggests that future recommendations on the use of CFIs might consider accounting for various factors, including skill, athletic background, or fitness levels.

The VO_{2peak} running protocol was designed to induce acute cardiorespiratory fatigue to assess the potential of CFIs on mitigating detriments to subsequent performance (17). Surprisingly, no significant declines in performance were observed in either condition following this protocol. These findings suggest that either the acute cardiorespiratory fatigue protocol was insufficient to induce observable neuromuscular changes, there was no effect of CFIs, or perhaps both. Furthermore, the improvement in jumping performance following the VO_{2peak} could be attributed to a learning effect, an inadequate warm-up, or post-activation potentiation (15). To progress the current protocol, a running protocol specifically targeting neuromuscular fatigue (11,16) may be superior in eliciting acute fatigue and therefore potential performance detriments. This study indicates peak aerobic power tests can be conducted prior to anaerobic tests without adverse consequences on performance, although a higher heart rate induced by the peak aerobic power test should be noted.

Any potential changes CFIs and other custom or stiff insoles have on biomechanics during running may be too trivial to significantly affect running economy in a recreational population (13,22) which may be why this study did not observe any meaningful physiological benefits while wearing CFIs during the VO_{2peak}. Furthermore, it is worth noting that previous studies have reported a beneficial influence of stiff insoles on running economy during similar or shorter running bouts (21,29,34). However, there is a need to further explore their effects on longer steady state runs in a moderately active population sample, as this would provide valuable insights into their practical applicability and potential benefits (22). An interesting finding of this study was an increase in respiratory exchange ratio during running at 85% of maximal speed while wearing CFIs, despite no changes in VO_2. This observation is consistent with previous studies in untrained subjects (4,30). On initial interpretation, these results may indicate CFIs alter substrate utilization with a shift towards a greater proportion of carbohydrate use as the source for energy during submaximal running (39). However, it is important to consider other potential sources or variability. Among the variables that have the largest effect on respiratory exchange ratio variability, sex, exercise duration, exercise intensity, and dietary intake (33), only dietary intake was not held constant between the CFI and CON trials. Despite participants being asked to consume a relatively average diet for the 24 hours before each trial, daily fat and carbohydrate dietary intake could have varied between the trial days. Furthermore, a recent modeling approach found participant diet, exercise, and physiological characteristics only explain about 60% of the variation in respiratory exchange ratios (33). In summary, the 95% CI of the difference between our conditions in the respiratory exchange ratio (0.01 to 0.05) is statistically significant but may not have substantial clinical relevance. The interplay of multiple factors, the normal physiological fluctuations in respiratory exchange ratios, the variability in dietary intake, and the multifaceted nature of exercise performance all contribute to the limited clinical significance of this small difference in respiratory exchange ratios.

Participants reported increased feelings of "*propulsion or explosiveness*" and being able to "*perform better while jumping*" when wearing CFIs despite no objective performance benefits. Due to the inability to blind participants to the insole type and purpose of the study, participants responses were likely biased and may have had heightened their performance expectations when wearing CFIs (32). Contradicting to previous literature, these perceptions did not have an effect on performance outcomes or may have lowered the effort participants applied, rather than benefited performance outcomes (26,44). This is further supported by the results of the VO_{2peak}; although VO_2 and heart rate values were similar between conditions, participants reported lower perceived fatigue and exertion when wearing CFIs. Efforts should be made in future studies to incorporate blinding methods to minimize potential biases in subjective evaluations of insoles and gain deeper insights into the subjective motivation underlying the adoption of CFIs.

To the knowledge of the authors, this is the first study to assess the effects of CFIs on VJ and sprint performance outcomes and perception of performance specific in moderately active participants. The results indicate that CFIs may enhance perception of performance without affecting objective performance outcomes. The data are novel and provide additional insights into the considerations required for determining use of CFIs. However, this study is not without its limitations, such as the protocol's inability to elicit subsequent performance deficits. Future studies should incorporate neuromuscular fatiguing protocols to evaluate the effects of CFIs on mitigating performance decline due to fatigue. While this study incorporated an adaptation phase for each insole similar in duration to that of other studies (29,34), the activity type and duration of use by participants was not recorded. Furthermore, one familiarization trial may not have been sufficient to eliminate learning effects and decrease intra-individual outcome variability for performance assessments in this population (19,43). Future studies including direct comparisons of moderately active individuals with elite athletes would help to determine the impact of skill and fitness levels on performance outcomes between conditions. Finally, the current body of evidence is not conclusive regarding the relationship between optimal CFI stiffness and body mass (34). As such, having CFI stiffness scaled to body mass may have added noise to the metabolic response, which could potentially explain a lack of significant effects on metabolic measures between conditions.

Increasing our understanding of the anticipated effects of CFI use on performance outcomes within specific populations can improve individualization for both users and clinicians. The heightened perceptions of performance enhancements reported by participants when wearing CFIs demonstrates the influential role of perceptual benefits in determining the use of CFIs among moderately active individuals. Consequently, from a practical standpoint, this study suggests that clinicians should not anticipate notable improvements in performance when advising or evaluating the use of CFIs for moderately active individuals or recreational athletes. Instead, they should consider the potential for an augmented perception of performance after a gradual integration of CFIs over a period of approximately 10 days. It is crucial to acknowledge the considerable variability observed in performance outcomes within this study, reinforcing the necessity of accounting for individual characteristics such as skill level, fitness level, anthropometrics, and running style, as well as the specific type of activity (e.g., jumping, sprinting, running), when recommending or implementing the use of CFIs for performance enhancement. While this study contributes valuable objective results on the impact of CFIs on performance outcomes, it also highlights important gaps in our current understanding, particularly the need for future investigations that incorporate neuromuscular fatiguing protocols and direct comparisons between moderately active individuals and elite athletes.

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